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Morphometric Study of Knee Cap (Patella).

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ABSTRACT

Background: Patella (kneecap) is the largest sesamoid bone in the human body which develops within the tendon of the quadriceps femoris muscle. It is significantly important in anthropometrics. It is involved in the various methods of sitting and squatting. Therefore, it will be modified by cultural and ethnic variables. The knowledge of morphology and dimensions of patella performs very important role in the design of prosthesis and development of surgical techniques, hence this work was undertaken to establish such data on the dimensions of patella. **Methods:** 50 dry human patellae collected from the Department of Anatomy, SAMC and PGI Indore, MP, India. The various parameters were recorded and photographed. **Results:** 82% patella are triangular. Mean of height, width and thickness of patella were 36.66, 38.66, 19.26 mm. Width of MAF and LAF is 20.69 mm, 23.35 mm. Surface area of medial and lateral articular facet of patella were 415 mm2 / 526 mm2. Average weight of the patella is about 7.9 gm. **Conclusion:** This study provides various morphometric parameters and original data in relation to the patellar facets. Data are applicable to implant design of the patella and important from a biomechanical perspective.

Keywords: Knee cap, Patella, Sesamoid bone.

INTRODUCTION

Patella is also called as kneecap,[1] commonly described as a flat, triangular bone, situated on the front of the knee joint.[2,3] It is the largest sesamoid bone in the human body which develops within the tendon of the quadriceps femoris muscle. (QF).[1,4] It is a flat bone 'poised like a shield' on the anterior surface of the femoral condyles,[4] serving to protect the front of the joint, & increase the leverage of the QF by making it act at a greater angle.[2]

It has two surfaces (anterior and posterior), three borders (superior, medial and lateral) and an apex pointing inferiorly[4,1] which gives attachment to the ligamentum patellae.[5] With the knee extension, the apex is just proximal to the line of the knee joint.[6] The subcutaneous, convex anterior surface is longitudinally ridged, separated from the skin by a prepatellar bursa, and perforated by nutrient vessels.It is covered by an expansion from the tendon of QF.[6] The posterior surface of the patella can be divided into two parts: superior (articulating) and inferior (non-articulating). The inferior part forms the apex of the patella which serves as a site of attachment for the patellar ligament.[4] The superior part, however, is sub-divided by a vertical ridge into lateral and medial facets in order to fit with the reciprocal patellar articular surface of femur.[5] Lateral facet is usually larger.[7,6] The thick superior border also called base8 slopes anteroinferiorly.[6] The medial and lateral borders are thinner & converge distally.[6]

Patella, as a bone, is significantly important in anthropometrics. It is involved in the various methods of sitting and squatting. Therefore, it will be modified by cultural and ethnic variables.[9]

Patella is prone to the trauma as it is subcutaneously placed and can be affected by any systemic skeletal disorder. The success of total knee arthroplasty or patellofemoral arthroplasty depends on obtaining the suitable patellar implant size.[10] There are very few studies on morphology of patella and the knowledge of morphology and dimensions of patella performs very important role in the design of prosthesis and development of surgical techniques, hence this work was undertaken to establish such data on the dimensions of patella.

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MATERIALS AND METHODS

The experimental sample consisted of 50 dry human patellae (25 right sided and 25 left sided) of unknown age and sex collected from the Department of Anatomy, Sri Aurobindo Medical College and Post Graduate Institute Indore, Madhya Pradesh, India.

The measured morphometric parameters for each patella included

1. Two patellar heights measurement (H1, H2):
   - H1: Total height of Patella (Linear distance between the superior border and the apex)
   - H2: Height of articular surface
2. Patella width (W) was calculated as the maximum distance between the medial and lateral borders of patella.
3. Patella thickness (T) was measured at the level of the midpoint of the facetal ridge.
4. Width of medial articular facet (WMAF) was calculated as the maximum width from the medial border to the median ridge.
5. Width of lateral articular facet (WLAF) was calculated as the maximum width from the lateral border to the median ridge. These measurements were taken using sliding vernier calliper.
6. The weight (WT) of each patella was measured using an electronic balance.
7. The surface area of each of the lateral (SLAF) and medial (SMAF) patellar facets was measured. Articular facets were mapped out on the graph paper with the help of transparency and surface area was obtained. We counted the smallest square of graph paper. (1 smallest square = 1mm). (Figure 2).
8. We also noted the shape of patella.

RESULTS

Table & Figure 1: Percentage of the shape of Patella (R- Right sided / L- Left sided)

Shape	Percentage (%)
Triangular	R – 80 L – 84
Rounded	R – 12 L – 12
Irregular	R – 8 L – 4

Table 2: Measurements of the patella (R- Right sided / L- Left sided)

Observations	Total Height (mm) H1	Height of Articular surface (mm)H2	Width (mm)	Thickness (mm)	WMAF (mm)	WLAF (mm)	Weight (gm)	SMAF mm2	SLAF mm2
Maximum	R-42.96 L-42.6	R-29.66 L-32.87	R-44.8 L-44.86	R-21.35 L-21.51	R-24.84 L-24.63	R-28.18 L-27.84	R-12.13 L-13.47	R-671 L-633	R-634 L-742
Minimum	R-29.17 L-32.25	R-18.02 L-20.37	R-31.64 L-30.36	R-16.58 L-16.64	R-16.87 L-17.94	R-17.41 L-21.3	R-2.9 L-5.01	R-262 -256	R-346 L-395
Average	R-36.61 L-36.72	R-24.46 L-25.74	R-38.80 L-38.53	R-19.21 L-19.31	R-20.94 L-20.44	R-22.73 L-23.97	R-7.4 L-7.7	R-424 L-406	R-518 L-535

Table 3: Comparison Between measurements of right and left sided patella

Observations	Right	Left
H1 (mm)	36.61	36.72
H2 (mm)	24.46	25.74
W (mm)	38.80	38.53
T (mm)	19.21	19.31
WMAF (mm)	20.94	20.44
WLAF (mm)	22.73	23.97
WT (gm)	7.4	7.7
SMAF (mm2)	424	406
SLAF (mm2)	516	535

The various parameters were recorded and photographed. [Table 1, 2 & Figure 1-3]. Data was analysed by calculating mean. Median, standard deviation (SD), students' T test [Table 4].

Maximum total height (H1) of right sided patella was 42.96 mm and minimum was 29.17 mm (mean 36.61 mm) whereas maximum total height (H1) on left sided patella was 42.6 mm and minimum was 32.25 mm (mean 36.72 mm). [Table 2].

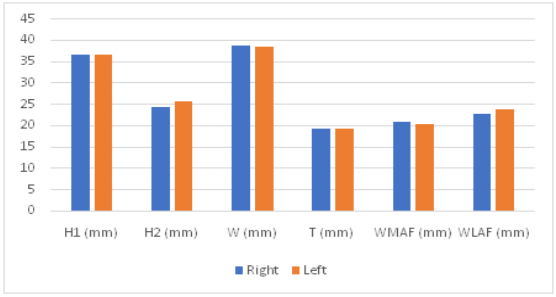
Maximum height of articular surface (H2) of right sided patella was 29.66 mm and minimum was 18.02 mm (mean 24.46mm) whereas maximum height of articular surface (H2) of left sided patella was 32.87 mm and minimum was 20.37 mm (mean 25.74 mm). [Table 2]. Average width of the patella is 38.66 mm (R -38.80 mm/ L- 38. 53 mm). [Table 2,3]. Thickness of the patella is about 19.26 mm (R-19.21 mm / L -19.31 mm). [Table 2,3] Average width of medial articular facet (WMAF) and lateral articular facet (WLAF) of right sided patella were 20.94 mm/ 22.73 mm and on left side it was 20.44 mm / 23.97 mm. [Table 2,3]

Average weight of the patella is about 7.9 gm (R-7.4 gm / L- 7.78 gm). [Table 2] Average Surface area of medial (SMAF) and lateral articular facet

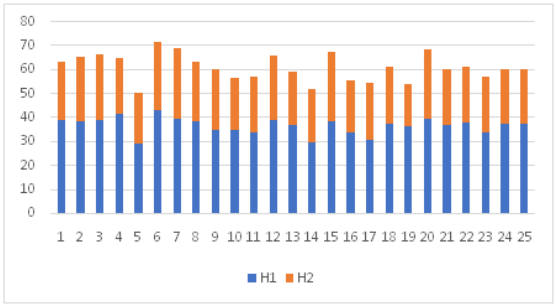
(SLAF) of right sided patella were 424 mm2 / 518 mm2 and on left side it was 406 mm2 / 535 mm2 respectively. [Table 2,3].

Table 4: Statistics of measurements of Patella

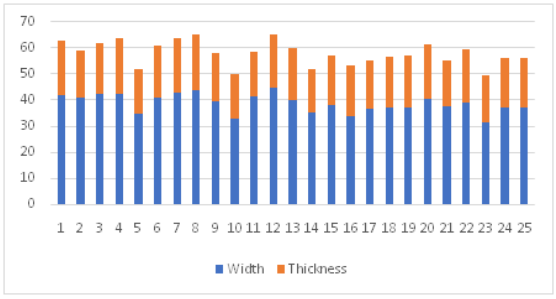
Observations	Total Mean	Median	Standard deviation	T Test
H1	36.67	37.06	3.38	0.91
H2	25.10	23.84	3.29	0.17
W	38.67	39.14	3.41	0.78
T	19.26	18.92	1.33	0.80
WMAF	20.70	20.29	1.89	0.35
WLAF	23.36	23.64	2.23	0.05*
WT	7.60	6.98	2.36	0.57
SMAF	415.34	410	97.85	0.52
SLAF	526.54	530	80.58	0.46



Graph 1: Comparison between right & left patella



Graph 2 : Ratio Between H1 H2 (Right side)



Graph 3: Ratio Between Width & Thickness (Right)

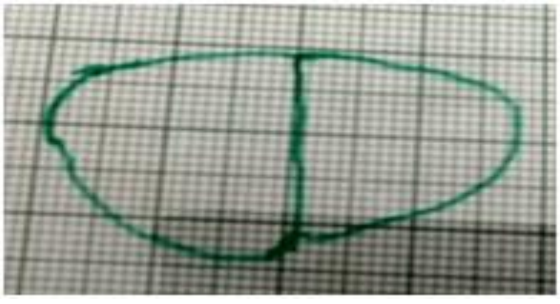


Figure 2: measurements of surface area of articular facets.

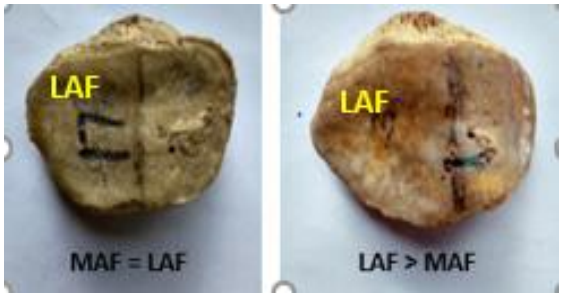


Figure 3: showing articular facets

DISCUSSION

Patella is significantly important in anthropometrics. It is involved in the various methods of sitting and squatting. Therefore, it will be modified by cultural and ethnic variables. It is to be assumed that the size and shape of the patella, can be dependent on the strain generated by the quadriceps muscle.[9]

In the present study 82% patella are triangular (80% on right side and 84% left side). 12 % patella are rounded on both the side. 6% patella are irregular in shape (8% on right side and 4% on left side). [Table 1, Figure 1]. Borges et al.[2] (2016) described 67. 6 % triangular, 21.6 % oblong, and 10.81% irregular patellas. The probable reason for the difference in the percentage of shape of patella can be accounted for the difference in the races, age and height of two group studied. Posture and physique possibly have a direct effect on the shape of the sesamoid bone (patella) within its tendon (quadriceps femoris). but the exact contributions of these factors could not be ascertained in this study.

In the present study mean height, width and thickness of patella were 36.67 mm (SD 3.38), 38.67 mm (SD 3.41), 19.26 mm (SD 1.33) mm which was correlated with study by Murugan et al.[2] (2017) where mean height, width and thickness of patella were 38.07 mm (SD 3.79), 38.58 mm (SD 3.81), and 18.29 mm (SD 1.73) respectively. The mean values reported by Imam et al.[6] (2016) were: 36.95 mm (SD 4.52) (Total height), 38.21 mm (SD 3.99) (Width), 18.70 mm (SD 1.82) (Thickness) which were comparable with present study.

Vohra p et al.[1] (2017) described mean of patellar height, and patellar thickness were 41.55 mm, 40.17 mm. which was higher than present study but patellar width which was 19.29 mm completely correlated with our study. Although the reasons for these variations have not been validated, it has been suggested that differences in measuring methods, sexes, age and body mass index could be contributing factors. A strong correlation was found between the width and thickness of the patella. In the present study width to thickness ratio of patella is 2:1 [Graph 3]. The width of the patella has been suggested to be a dependable factor for predicting the normal size of patella thickness as

well as for helping surgeons to decide on the thickness of the patella prosthesis during arthroplasty.[4] Thickness of a patellar implant is important. A disproportional implant of the patellofemoral joint would result in limitation of movement, excessive wear and instability of the patella with associated knee pain.[4]

In present study width of MAF and LAF is 20.69 mm, 23.35 mm respectively. Murugan et al.[7] (2017) described the width of the MAF was 18.78 mm and the width of the LAF was 22.75 mm which were slightly lower than present study. They also described similar studies done on other populations like Chinese, Koreans and Westerners in whom the values of width of MAF were 19.03 mm, 18.4 mm and 18.8 mm respectively and values of width of LAF were 25.1 mm in Chinese, 23.3 mm in Koreans and 25.3 mm in Westerners respectively (Peng et al.) (2014)[11], which were correlated with present study.

Patellae were also classified based on the dimensions of the articular facets. Olateju et al.[4] (2013) in their article cited the work of Wiberg (1941)[12] who reported the classification of patella into three categories. According to Wiberg's classification, a Type I patella is defined as a patella whose MAF and LAF widths are concave and equal. A Type II patella is one in which the width of the MAF is flat or slightly convex and smaller than the width of the LAF. In Type III patellae, however, the width of the MAF is convex and considerably smaller than the width of the LAF. They also cited another study on the classification of the patellae of foetal cadavers, Koyuncu et al. (2011),[13] reported that 20% of patellae was Class A (the widths of MAF and LAF are equal). In addition, Class B (the width of the MAF is smaller than the width of the LAF) was reported as the most prevalent (50%) while 30% of patellae was Class C (the width of MAF was greater than the width of the LAF).

In the present study based on the dimension of WMAF in relation to WLAF, each patella was classified into one of three categories: Type A (WMAF=WLAF), Type B (WMAF<WLAF) or Type C (WMAF>WLAF). 82% of the patellae in the studied sample were classified as Type B and 18% were Type A. We did not find Type C patella. [Figure 3].

In the present study, it was found that the Type B patella was the most prevalent, which is in support of previous observations by Wiberg et al. (1941),[12] and Koyuncu et al. (2011),[13] found Type B to be the most prevalent while Type C was the least prevalent. Despite the differences in the measuring parameters, the findings of the studies were similar.

In present study average Surface area of medial (SMAF) and lateral articular facet (SLAF) of right sided patella were 424 mm^2 / 518 mm^2 and on left side it was 406 mm^2 / 535 mm^2 respectively. [Table 2, Figure 2]. Imam et al.[3] (2017)stated the mean value of the lateral facetal surface area of right patellae was 5.25 cm^2 and Lateral facetal surface area of the left was 5.35 cm^2, which was completely in agreement with present study. In their study the mean of the medial facetal surface area of the right patellae was 3.74 cm^2 and Medial facetal area of the left was 3.33 cm^2 which was lower than our study. These data concord to the fact that the Surface area of the lateral facet is larger than the medial facet; this seems to be the case in right patellae and left patellae.

In present study Mean of total height (H1) is 36.66 mm (R- 36.61 mm /L- 36.72mm) and standard deviation is 3.40 whereas mean of height of articular surface (H2) is 25.10 mm (R- 24.46 mm/ L- mean 25.74 mm) and standard deviation is 3.24 [Table 2,4], which were in agreement with Imam et al.[3] (2017) who mentioned the mean of H1 and H2 36.95 mm, 27.43 mm respectively. They also described the mean of weight which was 9.834 gm. In our study average weight of the patella is about 7.9 gm (R- 7.4 gm / L- 7.78 gm) [Table 2], which is slightly lower. The reasons for these variations may be because of differences in measuring instrument, sexes, age and stature. We analysed the ratio between H1 and H2 which was 3:2 [Graph 2]. No other workers have described such type of ratio.

Student's t-test was used to determine whether significant difference existed between the right and left patella. According to Student's t-test there was no statistically significant difference in the measurements of the patella between the sides of the body, except for WLAF (p=0.05) [Table 4].

In present study there was no significant difference in the dimensions of all the measurements of right and left patellae [Table 3, Graph 1] which was similar to the study by Murgan et al.[7] (2017) and olateju et al.[4] (2013).

CONCLUSION

This study provides various morphometric parameters and original data in relation to the patellar facets. Data are applicable to implant design of the patella and important from a biomechanical perspective which will enhance the quality of life. Type B patella was the most common in Indian population. Various parameters that have been studied in the present work in Indian population can be utilized for orthopaedic surgery, anthropology, comparative anatomy, evolutionary Biology, and forensic evaluations.

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